From: Britton, Cathryn
Sent: Thursday, February 16, 2017 8:20 AM
To: Scott, Derek <Scott.Derek@epa.gov>; Roe, Lindsay <Roe.Lindsay@epa.gov>; Muhammad, Maryam K. <Muhammad.Maryam@epa.gov>
Cc: OPP RD Managers <OPP_RD_Managers@epa.gov>; Friedman, Dana <Friedman.Dana@epa.gov>
Subject: RE: EFED Presentations to Weed Science Society of America

Dana Friedman (copied here) is the PRD training point of contact.

Thanks,
Cathryn

From: Scott, Derek
Sent: Thursday, February 16, 2017 8:13 AM
To: Roe, Lindsay <Roe.Lindsay@epa.gov>; Muhammad, Maryam K. <Muhammad.Maryam@epa.gov>
Cc: OPP RD Managers <OPP_RD_Managers@epa.gov>
Subject: FW: EFED Presentations to Weed Science Society of America

Hi Team,

Mike and the BCs would like EFED to present these presentations to RD in a brownbag session for staff—information sharing and capacity building.

Mike would also like to invite PRD as well—Cathryn Britton could probably suggest a good point of contact.

Frank Farruggia and Ed Odenkirchen are the EFED presenters. I would start with them on getting things rolling.

Let me know if/how I can assist.

Thanks,

Derek Edmund Scott
Office of Pesticides Programs, Registration Division
703-305-6627
202-355-2941 (cell)
Scott.derek@epa.gov

From: Goodis, Michael
Sent: Wednesday, February 15, 2017 4:40 PM
To: Scott, Derek <Scott.Derek@epa.gov>
Subject: FW: EFED Presentations to Weed Science Society of America

Please coordinate with the training team.
I asked Marietta and she is agreed.
May want to coordinate with PRD too. Thanks

Michael L. Goodis, P.E.
Director, Registration Division (RD)
Office of Pesticide Programs (OPP)

Phone 703-308-8157
Room S7624

From: Goodis, Michael
Sent: Wednesday, February 15, 2017 8:06 AM
To: OPP RD Managers <OPP_RD_Managers@epa.gov>
Subject: FW: EFED Presentations to Weed Science Society of America

FYI

I wonder if it would be good to ask EFED to hold a brown bag or something for our staff on this material. Let's talk about it at staff today.

Michael L. Goodis, P.E.
Director, Registration Division (RD)
Office of Pesticide Programs (OPP)

Phone 703-308-8157
Room S7624

From: Echeverria, Marietta
Sent: Tuesday, February 14, 2017 9:20 AM
To: Goodis, Michael <Goodis.Michael@epa.gov>; Guilaran, Yu-Ting <Guilaran.Yu-Ting@epa.gov>; Miller, Wynne <Miller.Wynne@epa.gov>
Subject: FW: EFED Presentations to Weed Science Society of America

FYI

From: Farruggia, Frank
Sent: Tuesday, February 14, 2017 9:07 AM
To: OPP EFED <OPP_EFED@epa.gov>
Subject: EFED Presentations to Weed Science Society of America

Hello EFED,

Attached are the two talks that Ed and I presented at the WSSA meeting last week. Also attached is the Audrey III poster that was presented.

Please let us know if you have any questions.

Frank

_____
Frank T. Farruggia, Ph.D.
Environmental Fate & Effects Division
Office of Pesticide Programs, US-EPA
1200 Pennsylvania Avenue, N.W., Washington, DC 20460
Mail Code: 7507P
Phone: (703)347-0231

Audrey III- EPA's Tier II Plant Exposure Estimation Tool

Jim Carleton, Elizabeth Donovan, Frank Farruggia, Kris Garber, R. David Jones, Brian Kiernan, Ed Odenkirchen, Chuck Peck, and Dirk Young

U.S. Environmental Protection Agency, Office of Pesticide Programs

Introduction

EPA's Office of Pesticide Programs (OPP) is working to develop a new plant exposure estimation tool, Audrey III, which will incorporate refined methods for assessing exposure to plants in terrestrial and semi-aquatic environments. This model, which is a replacement for the current exposure plant model TerrPlant, may be used to address various protection goals, including habitat for animals, biodiversity of native habitats, plants of economic values, and species of special concern (e.g., endangered species). Audrey III will make better use of fate and transport data that are typically available for pesticides and will use the same crop scenarios (including soil and weather data) currently being used for Tier II surface water assessments. The Audrey III model will integrate spray drift and runoff into a single exposure assessment. **OPP intends to develop Audrey III into a stand-alone Tier II model that uses existing algorithms from the Pesticide in Water Calculator (PWC) for exposure assessments.**

Audrey III will replace the current plant exposure model with three distinct modules:
- *The Terrestrial Plant Exposure Module* which will replace the dry-areas portion of TerrPlant,
- *The Wetland Plant Exposure Module* which will replace the semi-aquatic portion of TerrPlant, and
- *The Aquatic Plant Exposure Module* which is the same as the current approach to assessing risk to aquatic plants (i.e., the standard pond model).
- The current exposure models used in OPP's ecological risk assessments for pesticides are available online at: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment

A comparison of major TerrPlant and Audrey III model assumptions is provided in Table 1.

Table 1. Comparison of TerrPlant and Audrey III Model Assumptions	
TerrPlant Assumptions	**Audrey III Assumptions**
Runoff EECs	
Single application Incorporation depth Solubility • <10 ppm: 1% or 10% of application[1] • 10 to 100 ppm: 2% or 20% of application[1] • >100 ppm: 5% or 50% of application[1]	Multiple applications Precipitation Runoff Flow Physiochemical properties Physical processes
Spray Drift EECs	
Default values based on application method • Ground: 1% of application[1] • Aerial: 5% of application[1]	Based on AgDrift curves • Default assumptions or custom curves
[1] Application in lb a.i./A	

Conceptual Models New to Audrey III

Figure 1. Terrestrial Plant Exposure Model Conceptual Model

Figure 2. Wetland Plant Exposure Model Conceptual Model

Terrestrial Plant Exposure Module

Figure 1 depicts the ecological conceptual model for the terrestrial plant exposure module.
- The terrestrial plant community adjacent to a 10-ha treated field, referred to as the Terrestrial Plant Exposure Zone (T-PEZ), is exposed to pesticide via sheet flow and spray drift.
- The length of the T-PEZ is equal to the edge of the treated field (316 m).
- The width of the T-PEZ is equal to the distance that overland surface flow (or sheet flow) can travel before concentrated flow begins (30 m).
- The depth of the T-PEZ is equal to the typical active root zone of terrestrial plants (15 cm).
- Output is in lbs ai/A and is compared to vegetative vigor and seedling emergence endpoints (IC_{25} and $NOAEC/IC_{05}$ for growth).
- Sensitivity analysis indicates the module is sensitive to T-PEZ width (primarily) and depth.

Wetland Plant Exposure Module

Figure 2 depicts the ecological conceptual model for the wetland plant exposure module.
- The wetland plant community adjacent to a 10-ha treated field, referred to as the Wetland Plant Exposure Zone (W-PEZ), is exposed to pesticide via concentrated flow and spray drift.
- The W-PEZ is 1 ha, which is the same as the current pond model.
- The maximum depth of the water is set to 15 cm, but will be allowed to dry down using algorithms from the Variable Volume Water Model (VVWM).
- The depth of the sediment is based on the active rooting zone of typical wetland plants (15 cm).
- Output (lbs ai/A) is compared to vegetative vigor and seedling emergence endpoints (IC_{25} and $NOAEC/IC_{05}$ for growth).
- Additionally, concentration in water (μg ai/L) is compared to aquatic vascular and non-vascular endpoints (EC_{50} and $NOAEC/EC_{05}$ for growth).

Standard Pond also included in Audrey III

10 hectare field 100% treated

1 hectare x 2 m pond
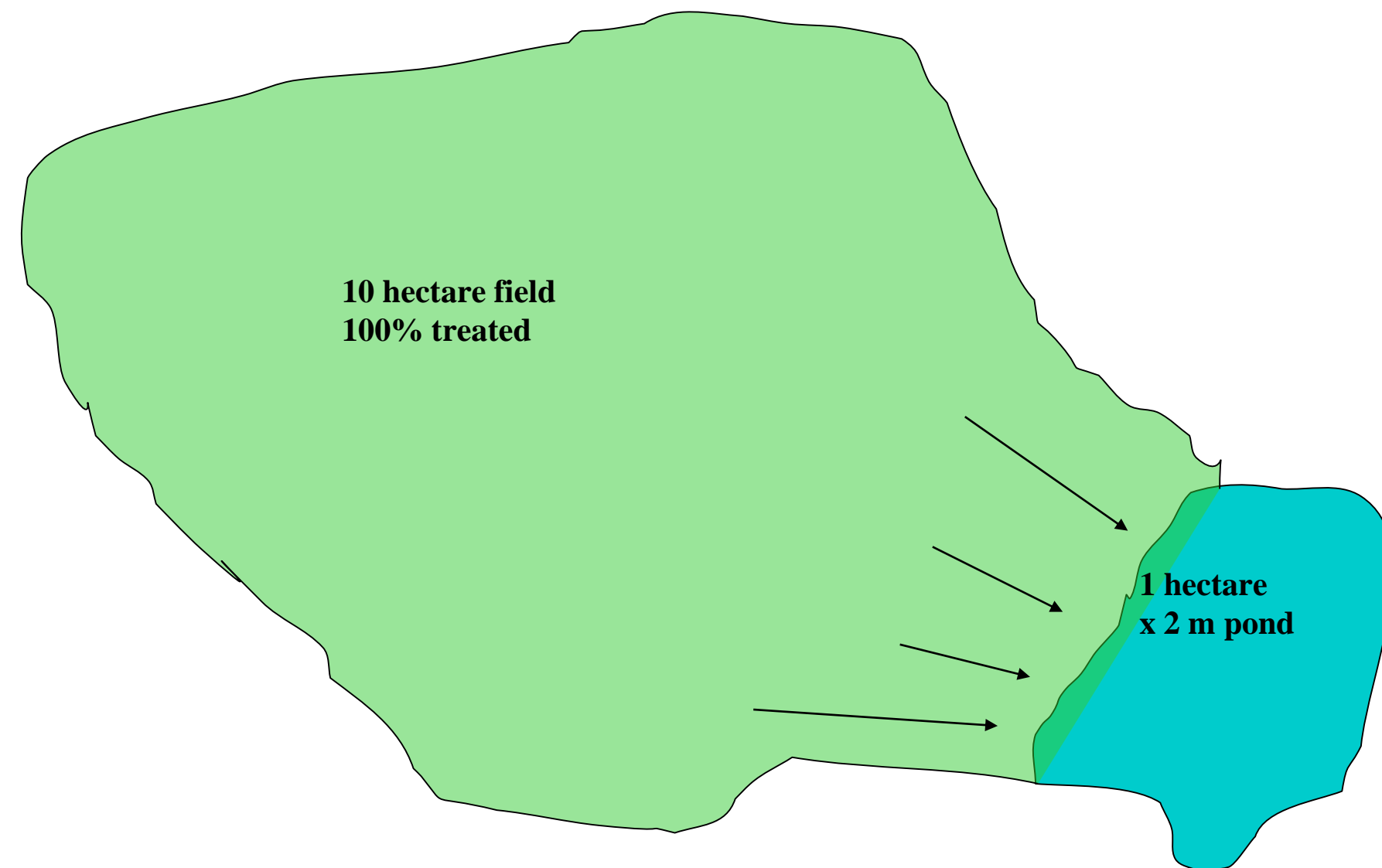
Figure 3. Aquatic Plant Exposure Model Conceptual Model

Aquatic Plant Exposure Module

Figure 3 depicts the ecological conceptual model for the aquatic plant exposure module. This module is the same as the current standard pond model used in aquatic assessments.
- The aquatic plant community within a pond (1 ha x 2 m) is exposed to pesticide via concentrated flow and spray drift from an adjacent 10-ha treated field.
- Output is expressed as a concentration in water (μg ai/L), which is compared to aquatic vascular and non-vascular endpoints.

Contact Information

Elizabeth Donovan: Donovan.Elizabeth@epa.gov
Frank Farruggia: Farruggia.Frank@epa.gov
Chuck Peck: Peck. Charles@epa.gov

T-PEZ Modeling Mechanics and Sensitivity Analysis

T-PEZ modeling algorithms account for the pesticide mass transport by runoff and erosion using Pesticide Root Zone Model [PRZM5] and by spray drift using AgDRIFT deposition curves. The model uses a mixing cell approach and accounts for water movement into and out of the T-PEZ with treated field runoff as well as the precipitation onto the T-PEZ. Pesticide losses from the T-PEZ are through degradation, leaching and runoff. Figure 4 illustrates T-PEZ model mechanics.
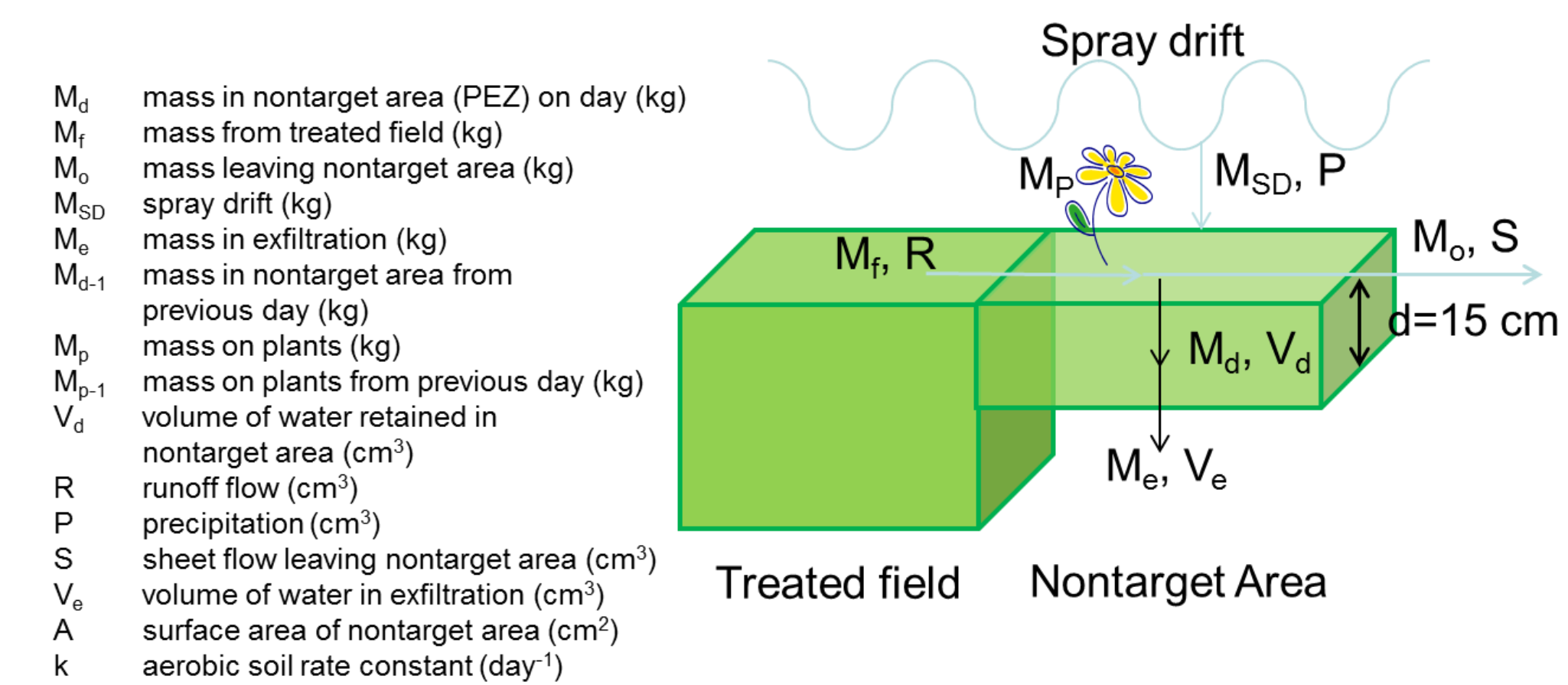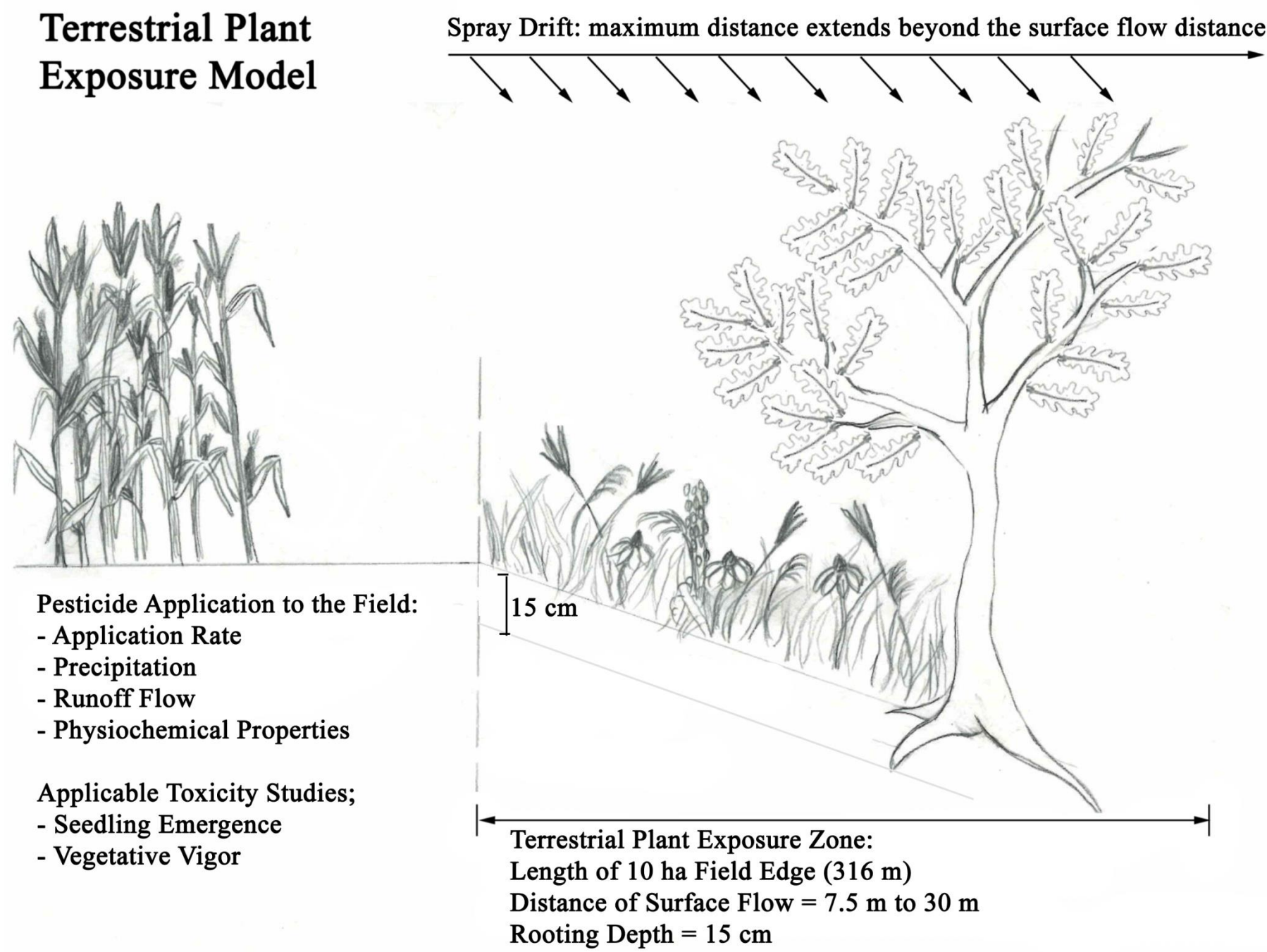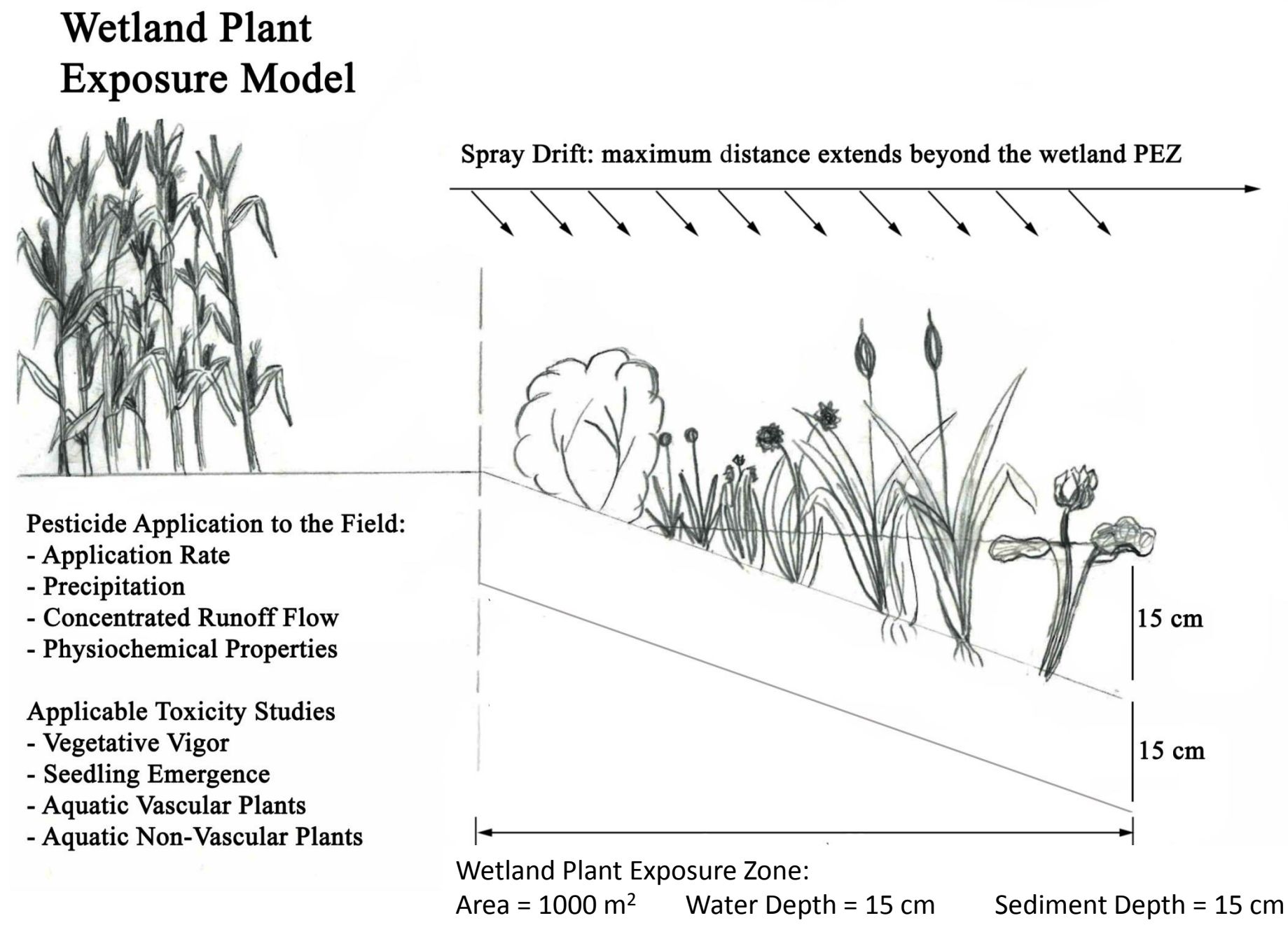

M_d	mass in nontarget area (PEZ) on day (kg)
M_f	mass from treated field (kg)
M_b	mass leaving nontarget area (kg)
M_{SD}	spray drift (kg)
M_e	mass in exfiltration (kg)
M_{o-1}	mass in nontarget area from previous day (kg)
M_p	mass on plants (kg)
M_{p-1}	mass on plants from previous day (kg)
V_d	volume of water retained in nontarget area (cm³)
R	runoff flow (cm³)
P	precipitation (cm³)
S	sheet flow leaving nontarget area (cm³)
V_e	volume of water in exfiltration (cm³)
A	surface area of nontarget area (cm²)
k	aerobic soil rate constant (day⁻¹)

Figure 4. Terrestrial Plant Exposure Model Components

A sensitivity analysis was conducted using Monte Carlo methods in Crystal Ball©. Several hypothetical chemicals and application rates covering a spectrum of physiochemical properties and application timings were used to examine the influence of runoff and persistence of the compound (Table 2). The results indicated that the most sensitive model parameters were T-PEZ width and soil depth. Soil bulk density, available water capacity, and curve number were also identified, but the model was much less sensitive to these parameters (Figure 5).

Table 2: Physiochemical Properties of Hypothetical Test Chemicals				
Chemical	Solubility Range (mg/L)	Kd Range	Aerobic soil half-life Range (days)	Hydrolysis Range (days)	Aerobic Aq half-life Range (days)
Compound A	1000+	0.1-0.5	10-100	Stable	10-100
Compound B	100-1000	0.5-1.0	1-10	Stable	10-100
Compound C	10-100	0.5-1.0	100-1000	Stable	100-1000
Compound D	1-10	1.0-5.0	1-10	0.25	1-10
Compound E	1-10	5.0-10	100-1000	Stable	10-100

Figure 5. TPEZ Model Sensitivity Analysis Identified that TPEZ Width and Depth Were Most Influential Parameters

W-PEZ Sensitivity Analyses

PRZM5 and VVWM, which make up the PWC, have undergone independent evaluations in their development and deployment histories, however the depths considered in the W-PEZ have not been evaluated before. A preliminary sensitivity analysis was conducted to evaluate the influence of the minimum depth on concentration. Depths of 0.5, 1, 1.5, and 2 cm were selected as minimum water depths that represent biological relevance to aquatic plant habitats. Results of this analysis indicate that the 1-in-10 year Estimated Exposure Concentrations (EECs) are relatively consistent between 2 and 0.5 cm depths (Table 3). However, when the minimum water level is allowed to drop below 1 cm, the estimated concentration rapidly increases for some compounds.

Table 3: Estimated Water Column EECs (ug a.i/L) Under Different Minimum Depth Restrictions					
	No min depth	Minimum W-PEZ Depth (cm)			
		0.5	1	1.5	2
Compound A	174	165	157	142	135
Compound B	2820	473	245	245	245
Compound C	163	163	163	147	145
Compound D	25.6	25.6	25.6	25.6	25.6
Compound E	6.7	6.7	6.7	6.7	6.7

Audrey III vs TerrPlant Comparisons

A comparison of EECs was conducted using a set of common compounds (Table 2) that represent different physiochemical properties. In TerrPlant, only solubility impacted model estimates. However, in Audrey III, the Kd, and aerobic soil, aerobic aquatic, and hydrolysis half lives influence EECs, and thus represent a more robust estimate of runoff concentration.

The resulting EECs for the T-PEZ are similar to the results from TerrPlant when assuming a corrected drift fraction representing 30 m off the field (Table 4). Comparison of the EECs of the W-PEZ to the TerrPlant Semi-Aquatic areas illustrates how incorporation of not only the conceptual design but also physiochemical properties have changed the EECs. For instance for a stable highly soluble compound (e.g., Compound B), the EECs in the W-PEZ have gone up roughly 20 fold, whereas for a stable and insoluble compound (e.g., Compound E), the EECs estimated by Audrey III are below those of TerrPlant.

Audrey III vs PWC Standard Pond Comparisons

As illustrated in Table 3, the depths considered in the W-PEZ influence EECs. This is also apparent when considering the comparison of the EECs between the W-PEZ and the PWC Standard Pond. The simulated field area and the pond surface area are the same for the two models, thus only water column depth and chemical movement (e.g., W-PEZ allows for overflow) are different.

The comparison of EECs reflect what is expected: higher EECs for the shallow W-PEZ than in the deeper Pond. The relative differences between chemicals indicate that the model is performing as anticipated with higher concentrations estimated for persistent and mobile chemicals (e.g., Compound B) and lowest concentrations with chemicals (e.g., Compounds D & E) that have less propensity to move in water because they are bound to sediment.

Next Steps

Audrey III is currently in the development phase. The team expects to continue to vet the model through the scientific community through publication and presentation to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel. Next steps including an evaluation of multiple application scenarios.

Table 4. Comparison of Audrey III, TerrPlant, and PWC Standard Pond EECs.							
	EECs for Audrey III and TerrPlant (lbs a.i./A)[a,b]					Audrey III WPEZ and PWC (ug a.i./L)[c]	
	Audrey III TPEZ	TerrPlant Spray Drift	TerrPlant Dryland: Spray Drift + Runoff	Audrey III WPEZ	TerrPlant Semi-Aquatic: Spray Drift + Runoff	Audrey III WPEZ Water Column	PWC Standard Pond
Compound A	0.3	0.2	0.3	7.3	0.7	157	19.8
Compound B	0.3	0.2	0.3	20.9	0.7	245	36.2
Compound C	0.3	0.2	0.3	8.3	0.4	163	45.5
Compound D	0.2	0.2	0.2	0.5	0.3	25.6	2.3
Compound E	0.3	0.2	0.2	0.2	0.3	6.7	0.5

[a]All compounds modeled using the IL_Corn scenario with aerial application on April 1st.
[b]TerrPlant Drift EECs assume the AgDRIFT Tier I Aerial drift fraction at 30 m for very-fine to fine droplets
[c]W-PEZ water column concentrations limited to 1 cm minimum depth.

Additional Research Needs

- The distance sheetflow run-off can travel before concentrated flow begins
- The typical active rooting zone depth for terrestrial environments
- The typical active rooting zone depth for wetland environments
- The minimum water depth for rooted and non-rooted aquatic plants
- Monitoring data for pesticides in vegetative filter strips (T-PEZ) and wetlands (W-PEZ)

Assessing Pesticide Risks To Plants: An overview of EPA's standard approach to plant risk assessments

Frank T. Farruggia, Ph.D.
Edward Odenkirchen, Ph.D.

Environmental Fate and Effects Division
Office of Pesticide Programs

Overview

- Pesticide Laws and Process Overview

- Environmental Fate and Toxicity Data

- Exposure and Risk Assessment Models

- Spray Drift

- Risk Estimation: RQs vs LOCs

- Risk Characterization: Certainties, Variability, Missing Data and Uncertainty

Federal Insecticide, Fungicide & Rodenticide Act (FIFRA)

- Governs the licensing, sale, distribution, and use of pesticides
- Labels ensure safe and proper use of pesticides
- When used according to its label, a pesticide "will not cause unreasonable risk to humans or the environment, considering economic, social, and environmental costs and benefits of the pesticide."
- *Risk-benefit standard*; considers human and ecological risk and benefits of pesticides
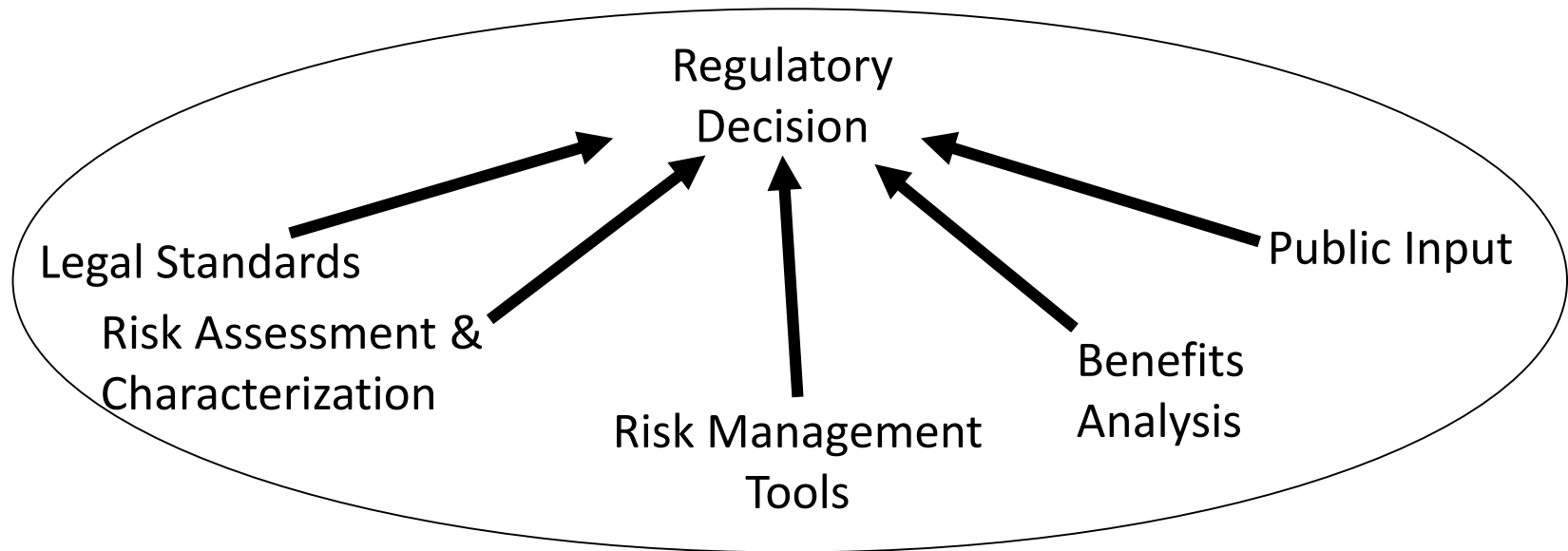
Ecological Risk Assessment: Factors Considered

- How is the pesticide used?
  - "Label is the law" principle
  - It is a violation of federal law to use a pesticide in a manner not in accordance with the label
  - Ingredients
  - Purpose of pesticide product
  - Sites and methods for application and pests to be controlled
  - Use directions and restrictions
  - Protective measures for humans and environment

- How frequently and to how much are non-target organisms exposed?
- How is the chemical formulated?
- What are the characteristics of the pesticide?

Environmental Fate Studies: Exposure

Pesticide degradation: Kinetics & process(es); parent and breakdown products

- Degradation studies: abiotic (hydrolysis, photolysis) & biotic degradation in soil and water (aerobic & anaerobic)

Mobility/transport: Movement of parent compound and breakdown products & potential for accumulation

- Mobility studies – movement in soil; drift & volatility
- Field dissipation - terrestrial, aquatic
- Accumulation in fish
- Higher tiered/special studies – e.g., prospective ground water monitoring

Environmental Effects Studies: Non-Target Plant Testing

- Code of Federal Regulations (CFR) 40 Part 158 Subdivision J requires testing of terrestrial and aquatic plants

- **Terrestrial Plants**
  - Parameters of interest include: Dry Weight, Height, Emergence and Survival
  - 10 test species (generally annuals, crops)
  - Seedling Emergence: 850.4100 (draft 850.4225; also 123-1a)
  - Vegetative Vigor Test: 850.4150 (draft 850.4250; also 123-1b)

- **Aquatic Plants**
  - Parameters of interest include: Biomass, Growth rate, Cell density
  - 850.4400 *Lemna sp.*
  - 850.4500 Green algae and Diatoms
    - *Pseudokirchneriella subcapitata, Skeletonema costatum, Navicula pelliculosa*
  - 850.4550 Cyanobacteria
    - *Anabaena flos-aquae*

Non-Target Plant Testing: Tiered Test Designs

- **Tier I (Limit Test)** seedling emergence, vegetative vigor and aquatic plant testing of a formulated /typical end-use product (TEP) should be conducted for <u>all</u> pesticides with outdoor uses.
  - At least the maximum application rate (lbai/A) should be tested
    - This rate should be the same as the registered or proposed TEP
    - Known phytotoxicants tested to max application rate are usually acceptable, provided a NOAEC is achieved
  - May use limit test as surrogate for NOAEC, must be <25% effect and not significantly different from control

- **Tier II (Dose Response)** studies are required if the Tier I studies indicate a >25% or 50% inhibition to any growth parameter relative to the control or the compound has known phytotoxic effects (*e.g.*, herbicides).
  - Intended to measure sublethal dose response of plants relative to a control
  - Measures the response of plants at five or more test rates to determine toxicity endpoints
    - IC_{25} (terrestrial); IC_{50} (aquatic)
    - NOAEC (or EC_{05}) for Listed Species

Non-Target Plant Testing: Data Review and Endpoint Selection

- All registrant-submitted studies submitted to the agency are reviewed and a summary document is produced (<u>D</u>ata <u>E</u>valuation <u>R</u>ecord, DER)
- Open Literature is screened for more sensitive endpoints and summaries are produced for studies included quantitatively or qualitatively (<u>O</u>pen <u>L</u>iterature <u>R</u>eview <u>S</u>ummaries, ORLS).

- Terrestrial studies: **most sensitive** monocot and dicot from the SE and VV studies are used to derive Risk Quotients (RQs).
- Aquatic studies: **most sensitive** of the four nonvascular studies and the *Lemna* endpoint for vascular plants are used to derive Risk Quotients (RQs).
- Toxicity data are compared to exposure estimates to derive risk
  - exposure/toxicity = Risk Quotient (RQ)
  - RQ compared to Level of Concern (LOC)
  - for plants, LOC is 1.0

Ecological Risk Assessment: Current Terrestrial Exposure Model (TerrPlant)

- Provides environmental exposure concentrations based on application rate, depth of incorporation, and method of application

- Pesticide exposure incorporates transport through:
  - Runoff, solubility (3 categories) and depth of incorporation
    - < 10 ppm: 1% of application
    - 10 to 100 ppm: 2% of application
    - >100 ppm: 5% of application
  - Drift
    - assumes 5% aerial, 1% ground spray
    - point deposition represents an ~200 ft distance from edge of field

Simple conceptual model of transport mechanisms influencing exposures of non-target plants to pesticides.

- Exposures are compared to terrestrial plant toxicity data for determining risk

- Assumptions:
  - Single application only
  - Other physiochemical properties do not critically influence runoff
  - Plant exposure in VV studies most closely approximates spray drift; no representation of runoff exposure
  - Exposure in SE studies is generally representative of both spray drift and runoff

Ecological Risk Assessment: Revisions to the Drift Exposure Estimate

- Switch from reliance only on TerrPlant to include AgDRIFT estimates (to a lesser extent AgDISP; September 2010)
  - Provide empirically-based deposition curves
  - Estimate distance from edge of field to where exposure does not exceed toxicity endpoints (*i.e.,* where RQ<LOC)

- Important Variables Affecting Spray Drift Levels
  - Droplet/Particle Size
    - Finer sprays are more drift prone
  - Release Height
    - Higher the boom height above the target, greater the potential for drift
  - Weather Condition
    - Higher winds speeds carry droplets farther
    - Lower winds may cause temperature inversions
    - Relative humidity and temperature can influence the droplet size

Ecological Risk Assessment: Revisions to the Drift Exposure Estimate

- Default parameters are typically used for modeling
- Specific enforceable label language allows for refinement of the default input parameters.

Advisory Language	Enforceable Language
■ The best drift management strategy is to apply the largest droplets that provide sufficient coverage and control.	■ Use coarse spray according to ASABE 572 definition for standard nozzles or VMD of 475 microns for spinning atomizer nozzles.
■ Make aerial or ground application when the wind velocity favors on target product deposition	■ Apply by ground boom with nozzle height no more than 2 feet above ground at wind speed ≤10 mph
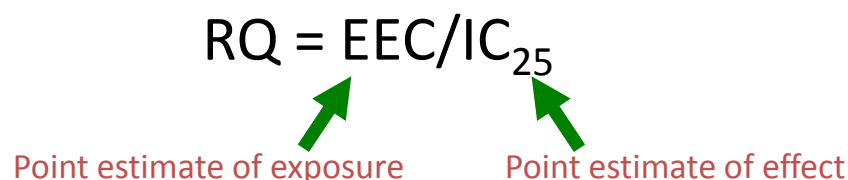
Ecological Risk Assessment: Current Aquatic Exposure Model (PRZM-VVWM)

- Pesticide Root Zone Model (PRZM) and the Variable Volume Water Model (VVWM) for aquatic exposure assessments.
  - Often referred to as the "Standard Pond" model.
  - The aquatic plant community within a pond (1 ha x 2 m) is exposed to pesticide via concentrated flow and spray drift from an adjacent 10-ha treated field.
  - Output is expressed as a concentration in water (µg a.i./L), which is compared to aquatic vascular and non-vascular toxicity endpoints.

10 hectare field
100% treated

1 hectare
x 2 m pond
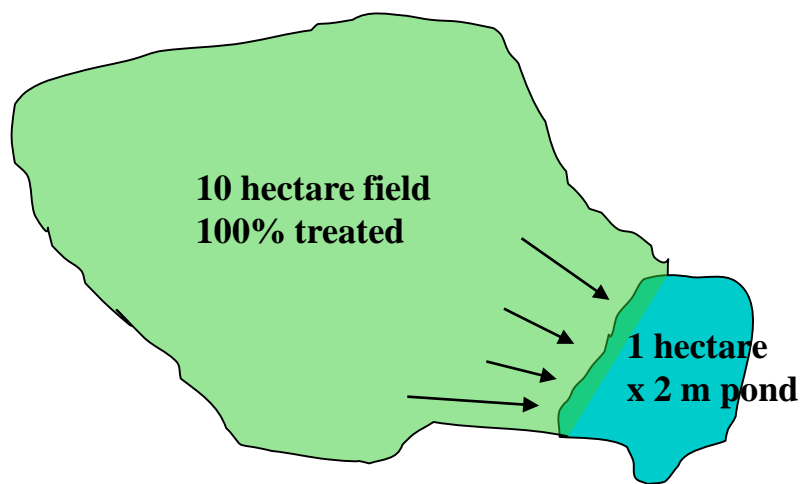
Ecological Risk Assessment: Risk Characterization

- A deliberate weight of evidence approach bringing all of the key considerations together

- Includes two major components: Risk Estimation and Risk Description

- For most chemicals, the risk estimation is based on a deterministic (point estimate) approach, (RQ method)

$$RQ = EEC/IC_{25}$$

Point estimate of exposure   Point estimate of effect

- RQ is a measure of the relationship of point estimates of exposure to point estimates of effect.

- The **maximum exposure** estimate is compared to the **most sensitive** estimate of toxicity.

- May also include probabilistic techniques

Risk Characterization: Risk Estimation

- Compare exposure and effects data

- Consideration of integrated exposure and effects data in context of LOCs

- State potential for risk

Plants

Risk Presumption	RQ	LOC
Plant Inhabiting Terrestrial and Semi-Aquatic Areas		
Acute Risk	EEC^1/IC_{25}	1
Acute Endangered Species	EEC/IC_{05} or NOAEC	1
Aquatic Plants		
Acute Risk	EEC^2/EC_{50}	1
Acute Endangered Species	EEC/EC_{05} or NOAEC	1

[1] EEC = lbs a.i./A
[2] EEC = (mg a.i./L or μg a.i./L) in water

Risk Characterization: Off-Site Exposure

Explore how far off the site of application effects are expected (e.g., spray drift analyses)

0.5 lb/A application rate; aerial app

Legend:
- Fine to Medium
- Medium
- Medium-Coarse
- Coarse
- Coarse-Very Coarse
- Very Coarse
- Very Coarse-Extremely Coarse
- Lowest Dicot IC25
- Lowest Monocot IC25

Y-axis: lb ai/A
X-axis: Distance Downwind from field (ft)
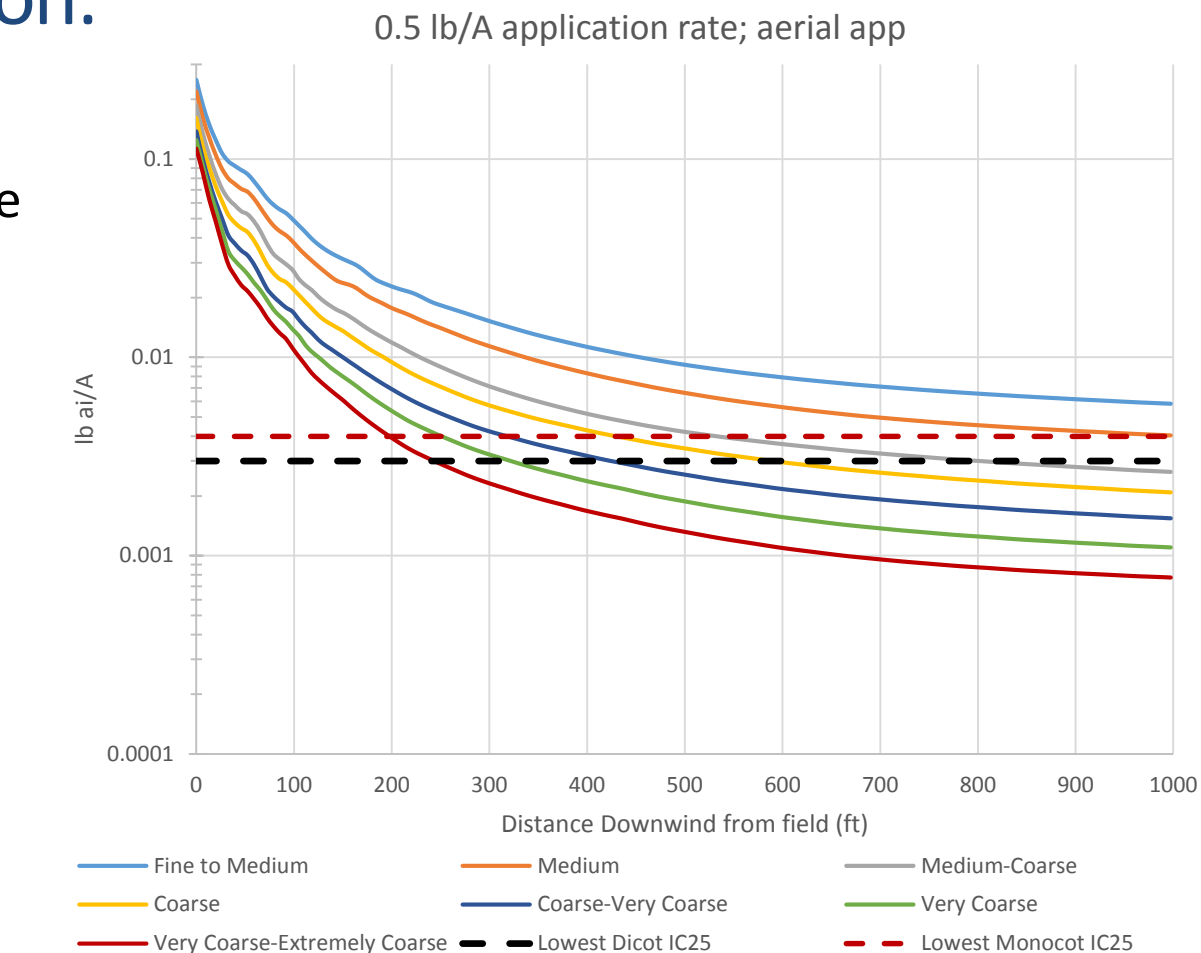
Risk Characterization: Risk Description

- Conclusions of risk are established through the process of integrating available information and its relevancy to assessment endpoints
  - More than simply a comparison of RQs to LOCs
  - Both quantitative and qualitative factors supporting or refuting risk finding
  - Characterization of risks to all tested plants is important in Risk Description
    - *e.g.,* all of the tested dicots and onion may be sensitive, but grasses are insensitive. Currently the most sensitive monocot would be onion. The risk description would incorporate this into the discussion of risk.

- What effects to the environment are expected from the registered use of the chemical?
  - What are the magnitude and probability of effects and how likely are they?
  - Are these effects likely to occur across different species?
  - Are these effects likely to impact populations or communities?
  - Will the effects influence the density and diversity of the species?
  - Will the effects to plants impact other taxa indirectly?

Weight of Evidence Approach

Risk Characterization: Risk Description

- **Adequacy and quality of data**
  - Were data quality objectives and guidelines adhered to?
  - What assumptions were made in light of data gaps?
  - Were experimental designs appropriate to answer the questions posed in problem formulation?

- **Degree and type of uncertainty**
  - Risk characterization presents the most significant sources of variability and uncertainty and how they inform the interpretation of the risk assessment
  - Data gaps should be clearly identified
  - **Variability** – Refers to observed differences attributable to heterogeneity or diversity in a population or exposure parameter
  - **Uncertainty** – Represents a lack of knowledge, which may or may not be reduced with additional studies

- **Relationship of evidence to risk assessment questions**
  - Significance of surrogate species to others in class
  - Discussion of open literature derived from ECOTOX
  - Consideration of sensitive ecosystems and organisms
  - Consideration of effects not reflected in data
    (*e.g.* reproductive effects)

Risk Characterization: Ecological Incidents

- **<u>Ecological incident</u>** = an event(s) in which a pesticide is known to or suspected of causing adverse effects to animals and plants other than the intended target species.

  - Incident data are used as a line of evidence for making risk conclusions in pesticide risk assessments.

Ecological Risk Assessment: Conclusions

Risk conclusions are based on the consideration of all of the available and relevant data

Case Studies Illustrating EPA's Process for Evaluating Plant Risk Mitigation Strategies.

Frank T. Farruggia, Ph.D.
Edward Odenkirchen, Ph.D.

Environmental Fate and Effects Division
Office of Pesticide Programs

Overview

- Risk Assessment Refinements and Other Considerations
  - Comparative Risk Across Species
  - Species Sensitivity Distributions
  - Geospatial Distribution of Risks
  - Exploration of Mitigation Measures for Reducing Risk

- Ongoing Work Related to Plant Risk Assessments
  - Variability in Controls for Guideline Terrestrial Plant Toxicity Studies
  - Development of "Audrey III" a New Terrestrial Plant Exposure Model
  - Mixtures and Responses Greater than Additive ("Synergy")

Comparing the Relative Risks Across Species

Drift Deposition Curves Compared to Vegetative Vigor IC$_{25}$ endpoints
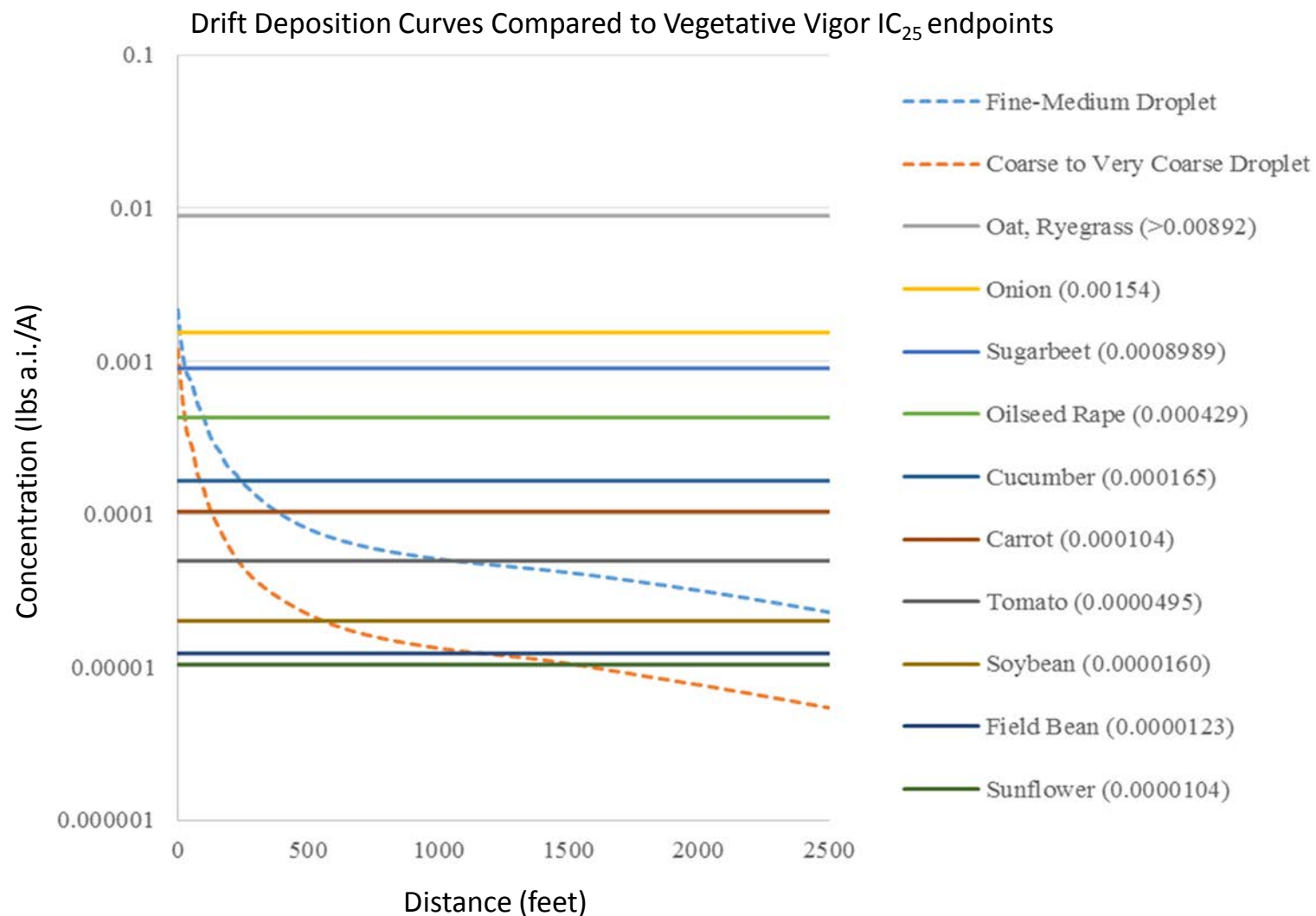
Species Sensitivity Distributions

- Useful for exploring risk to multiple species in risk assessments
- Integration of multiple studies and variable responses for individual species
- Can compare different Hazard Concentration (HC) values at risk
  - e.g., 5, 25, 50, 80 % of the species distribution

https://www.epa.gov/endangered-species/provisional-models-endangered-species-pesticide-assessments#Effects
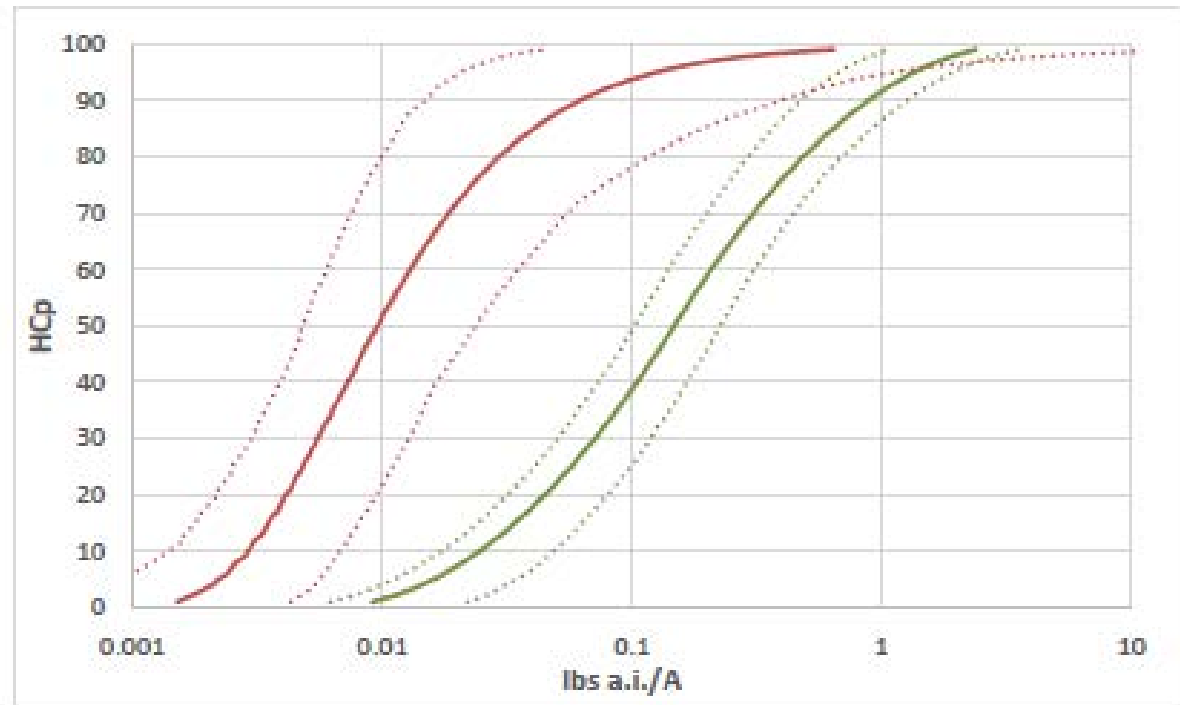
Atrazine Example: Geographic Distribution of Exposure and Risk

- Agricultural Footprint of Use
- Watershed Regressions for Pesticides (WARP)
  - USGS Model for Predicting Probabilities of Aquatic LOC Exceedances in Watersheds
- Spatial Aquatic Model (SAM)
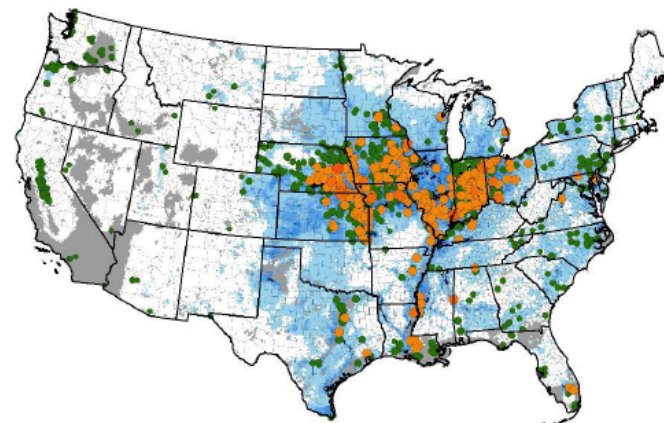 - EPA Watershed Model In-Development.

Estimated Agricultural Use for Atrazine , 2011
EPest-Low

Estimated use on agricultural land, in pounds per square mile
- < 3.14
- 3.14 - 18.11
- 18.12 - 64.23
- > 64.23
- No estimated use

https://water.usgs.gov/nawqa/pnsp/usage/maps/graphics/L_ATRAZINE_2011.png

Atrazine Footprint (CDL)
- Footprint
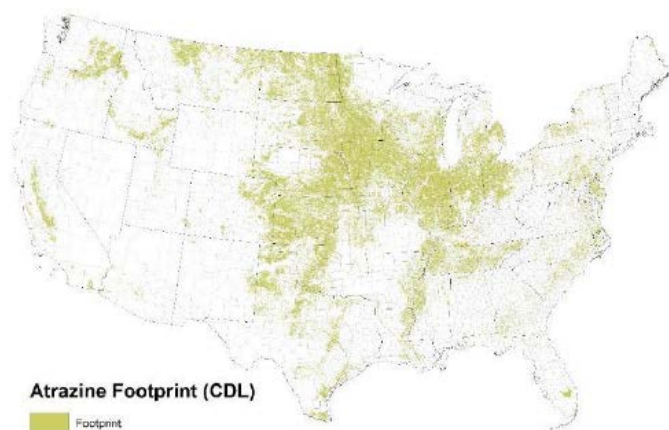
Figure 12. Cropland Data Layer (CDL) estimated agricultural layer for potential atrazine use sites for WARP.

Atrazine Monitoring Sites (µg/L)
CELOC
- 0 - 0.04
- 0.05 - 0.4
- 0.5 - 0.9
- 1.0 - 3.3
- 3.4 - 23
- 24 - 59
- 60 - 359
- 360 - 999
- 1000 - 2649
- 2650 +
- Use Exceeds WARP Maximum
- Inputs Outside WARP Bounds
60-day Avg. WARP Conc. (µg/L, 2006-09)
- 0.0 - 0.04
- 0.05 - 0.4
- 0.5 - 0.9
- 1.0 - 3.3
- 3.4 - 23
- 24 - 59
- 60 - 359
- 360 - 999
- 1000 - 2649
- 2650 +

Figure 3. Predicted and measured 60-day average atrazine concentration (µg/L) using WARP and the available georeferenced monitoring data illustrate the national risk picture for amphibians, fish, aquatic plants and communities. WARP generated concentrations (blue shading) represent the average predicted 60-day concentration based on agricultural use and weather input data for 2006-2009. Available georeferenced monitoring data with 12 or more samples are identified as green when the 60-day maximum average concentration is below the CELOC (3.4 µg/L) and orange to red when exceeding the CELOC and also represents risk to amphibians and fish.

Exploration of Risk Mitigation Options

- Additional modeling may be included to compare risks under different use conditions
  - Drift Reduction (e.g., coarser droplet spectra)
  - Application Method (e.g., ground vs. aerial sprays)
  - Soil Incorporation
  - Formulation (e.g., liquid vs. granular)
  - Setbacks/buffers from riparian and aquatic areas

Ongoing Work Related to Plant Risk Assessments

- **Variability in Controls for Guideline Terrestrial Plant Toxicity Studies**

- Development of "Audrey III" a new Terrestrial Plant Exposure Model

- Mixtures and Responses Greater than Additive ("Synergy")

Assessing Variability in Controls for Guideline Terrestrial Plant Toxicity Studies

- Evaluate the variability in the control response for dry-weight and plant height endpoints for standard species tested in Seedling Emergence and Vegetative Vigor studies

- Hypothesis Testing: Determine the power to statistically detect differences in effect given the current 850 guideline study designs and the control variability.

- Regressions and the IC_{25}: evaluate the point estimates such as the IC_{05}, IC_{25} and their utility as a risk assessment endpoint
  - Main question: are these parameter estimates meaningful differences from the control?
  - The use of the IC_{05} for listed species was a policy decision, this will be evaluated and revised if necessary based on the data

Ongoing Work Related to Plant Risk Assessments

- Variability in Controls for Guideline Terrestrial Plant Toxicity Studies

- **Development of "Audrey III" a new Terrestrial Plant Exposure Model**

- Mixtures and Responses Greater than Additive ("Synergy")

Audrey III- EPA's Tier II Plant Exposure Estimation Tool

- OPP intends to develop Audrey III into a stand-alone Tier II model that uses existing algorithms from the Pesticide Root Zone Model (PRZM) and the Variable Volume Water Model (VVWM) for aquatic exposure assessments.

- Audrey III will replace the current plant exposure model (TerrPlant) with three distinct modules:

    - *The Terrestrial Plant Exposure Module* which will replace the dry-area portion of TerrPlant,

    - *The Wetland Plant Exposure Module* which will replace the semi-aquatic portion of TerrPlant, and

    - *The Aquatic Plant Exposure Module* which is the same as the current approach to assessing risk to aquatic plants (*i.e.*, the standard pond model).

Audrey III- Terrestrial Plant Exposure Module

Terrestrial Plant Exposure Model

Spray Drift: maximum distance extends beyond the surface flow distance

15 cm

Pesticide Application to the Field:
- Application Rate
- Precipitation
- Runoff Flow
- Physiochemical Properties
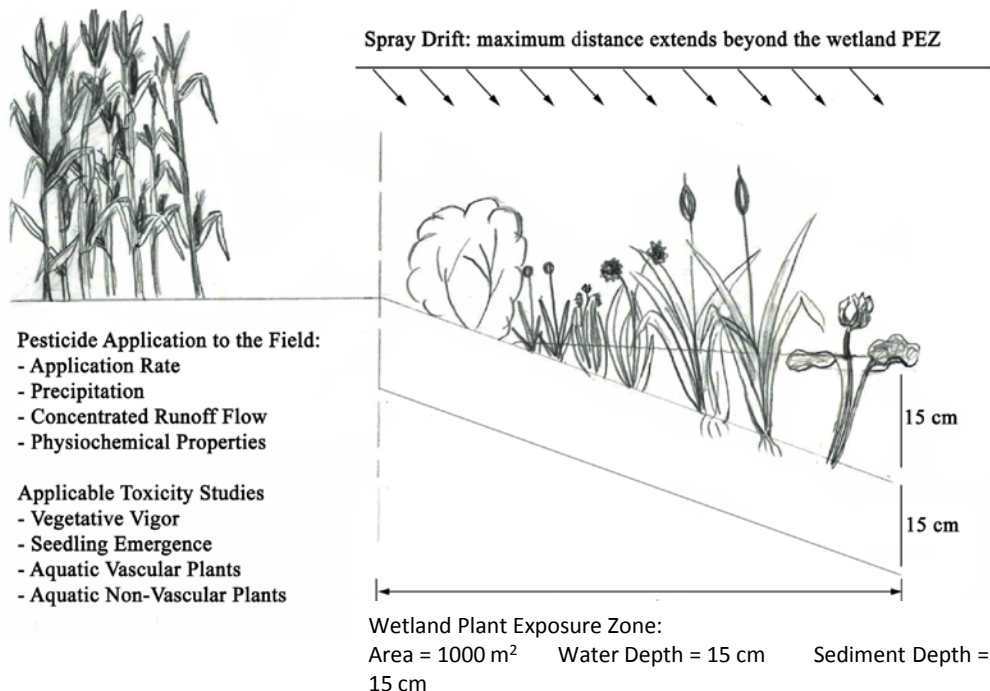
Applicable Toxicity Studies;
- Seedling Emergence
- Vegetative Vigor
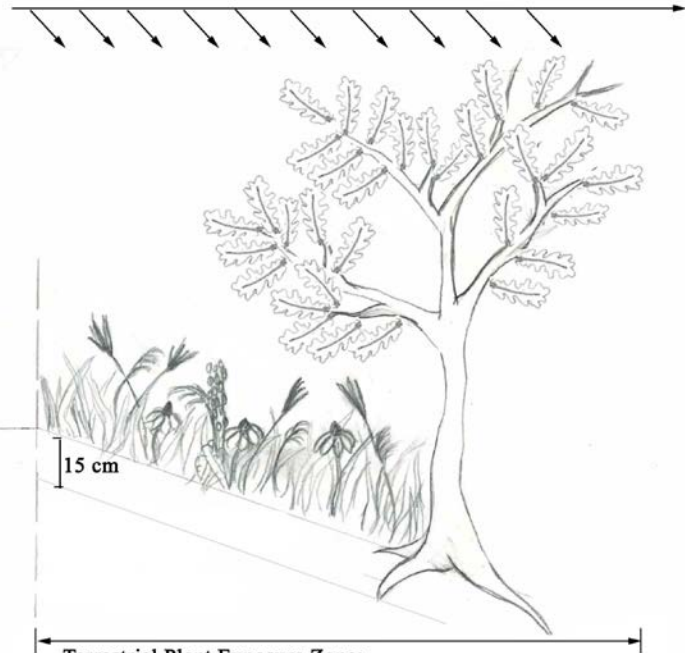
Terrestrial Plant Exposure Zone:
Length of 10 ha Field Edge (316 m)
Distance of Surface Flow = 7.5 m to 30 m
Rooting Depth = 15 cm

Terrestrial Plant Exposure Zone (T-PEZ):
- adjacent to a 10-ha treated field
- exposed to pesticide via sheet flow and spray drift
- length equal to the treated field edge (316 m)
- width equal to the distance that overland surface flow (or sheet flow) can travel before concentrated flow begins (30 m)
- depth equal to the typical active root zone of terrestrial plants (15 cm)
- Pesticide Root Zone Model (PRZM5) and AgDRIFT deposition curves
- Output:
  - lbs ai/A -compared to vegetative vigor and seedling emergence endpoints
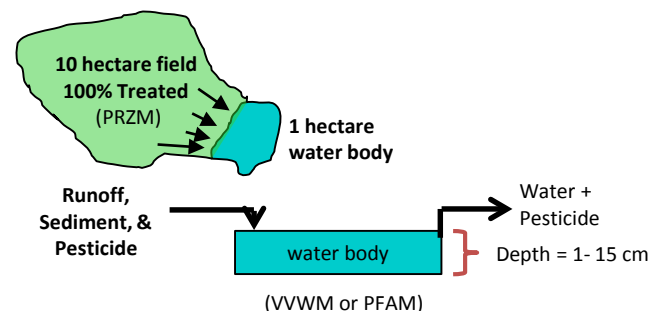
Audrey III- Wetland Plant Exposure Module

Wetland Plant Exposure Model

Spray Drift: maximum distance extends beyond the wetland PEZ

Pesticide Application to the Field:
- Application Rate
- Precipitation
- Concentrated Runoff Flow
- Physiochemical Properties

Applicable Toxicity Studies
- Vegetative Vigor
- Seedling Emergence
- Aquatic Vascular Plants
- Aquatic Non-Vascular Plants

15 cm

15 cm

Wetland Plant Exposure Zone:
Area = 1000 m² 　　Water Depth = 15 cm 　　Sediment Depth = 15 cm

Wetland Plant Exposure Zone (W-PEZ):
- adjacent to a 10-ha treated
- exposure via concentrated flow and spray drift
- area = 1 ha, same as the current pond model
- depth of the water varies = 1 cm to 15 cm
- PRZM5 and Variable Volume Water Model (VVWM)
- depth of the sediment = 15 cm
- Output:
  - lbs a.i./A - compared to vegetative vigor and seedling emergence endpoints
 - µg ai/L -compared to aquatic vascular and non-vascular endpoints

10 hectare field 100% Treated (PRZM)

1 hectare water body

Runoff, Sediment, & Pesticide

Water + Pesticide

water body

Depth = 1- 15 cm

(VVWM or PFAM)

Comparison of TerrPlant and Audrey III Model Assumptions

Table 1. Comparison of TerrPlant and Audrey III Model Assumptions	
TerrPlant Assumptions	Audrey III Assumptions
Runoff EECs	
Single application Incorporation depth Solubility • <10 ppm: 1% or 10% of application • 10 to 100 ppm: 2% or 20% of application • >100 ppm: 5% or 50% of application	Multiple applications Precipitation Runoff Flow Physiochemical properties Physical processes
Spray Drift EECs	
Default values based on application method • Ground: 1% of application • Aerial: 5% of application	Based on AgDrift curves • Default assumptions or custom curves

Audrey III- Aquatic Conceptual Model

- Aquatic Plant Exposure Module

    - Current standard pond model (PRZM-VVWM) used in aquatic assessments.

    - The aquatic plant community within a pond (1 ha x 2 m) is exposed to pesticide via concentrated flow and spray drift from an adjacent 10-ha treated field.

    - Output is expressed as a concentration in water (μg a.i./L), which is compared to aquatic vascular and non-vascular endpoints.

**10 hectare field
100% treated**

**1 hectare
x 2 m pond**
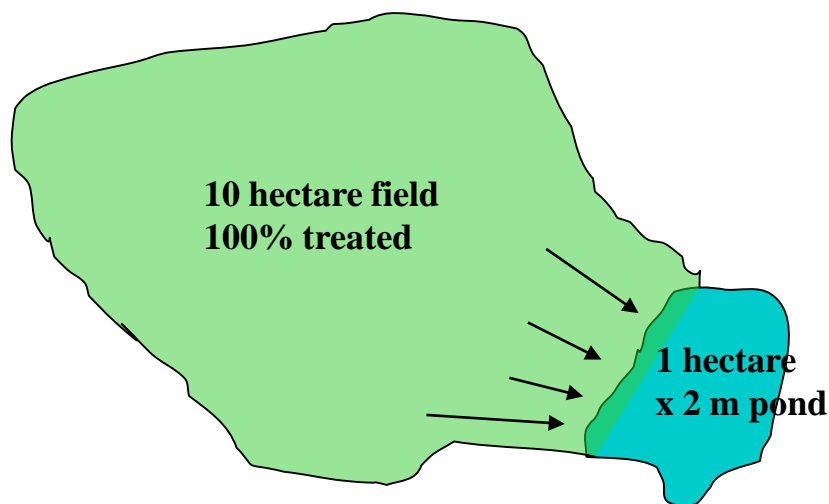
Ongoing Work Related to Plant Risk Assessments

- Variability in Controls for Guideline Terrestrial Plant Toxicity Studies

- Development of "Audrey III" a new Terrestrial Plant Exposure Model

- **Mixtures and Responses Greater than Additive ("Synergy")**

The Issue of Chemical Mixtures

- The current risk assessment model for ecological effects is largely based on "active ingredient alone" analyses

- The National Academy of Sciences (NAS) recommended that EPA's Office of Pesticide Programs (OPP) take into account the potential for multiple chemical stressor interactions, <u>when data allow</u>

- Publicly available literature and U.S patent claims have raised questions about the potential for synergistic activity between active ingredients

- OPP and Registrants have begun discussing options for evaluating patent data and addressing these questions

Goals for Assessment Approach for Claims of "Synergy"

- Appropriately consider additivity and "synergy" information in ecological risk assessments supporting regulatory decisions

- Efficient:
  - Limit the need for effects testing with every combination of active ingredients in formulations and other mixtures
  - Develop screening criteria based largely on current EPA scientific literature screening criteria

- Scientifically credible:
  - Identify lines of evidence on combined effects of mixtures beyond available formulated products testing
  - Include discussion as the information pertains to risk assessment conclusions

Initial Focus: Patents

- A large number of United States pesticide patents discuss the term "synergy"
- Not all these claims are necessarily technically relevant to a particular EPA registration decision
- EPA is not interested in refuting nor affirming claims made in patents and the findings of the U.S. Patent and Trade Office
- EPA is focused on evaluating patents for their data content and incorporating those findings into the lines of evidence used for regulatory decisions
  - Data receive appropriate evaluation relative to the risk assessment process
  - Determine if the data suggest a need to alter the risk assessment process, conclusions, or decision.

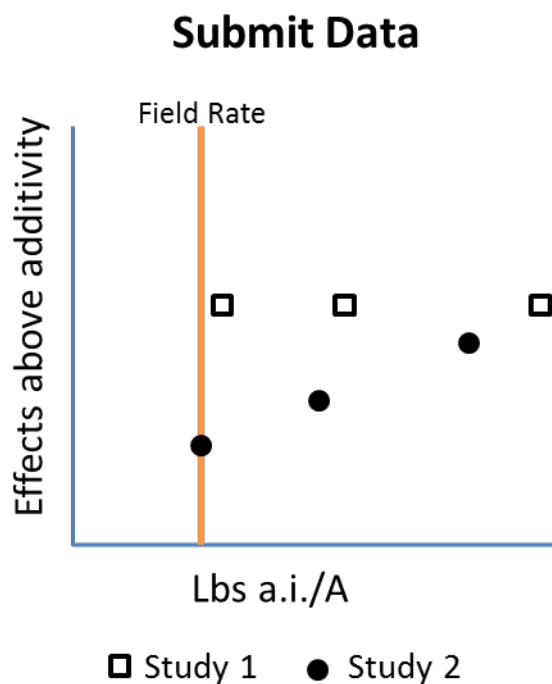# Current Relevance Criteria for Reporting

1. The patent contains some form of empirically based comparative analysis of effects

2. Patent or other mixture toxicity information must involve the testing of effects in taxa that are included in ecological risk assessments: mammals, birds, terrestrial and aquatic macroinvertebrates, fish, terrestrial and aquatic plants.

3. Reported effects must be direct measures on the taxon under consideration: *e.g.*, herbicide plant damage, animal survival, animal counts.

4. Patent mixture toxicity information must involve the testing for effects using the active ingredient under regulatory consideration: tested active ingredients have U.S. registrations.

Current Relevance Criteria for Reporting

- Studies not meeting criteria 1 - 4 should be documented by the registrant with patent identifier along with a rationale for exclusion from further data reporting.

- At this point, only the data fitting patterns for criteria 5- 7 are being requested for submission to the Agency.
  - Data that are useful for quantitative consideration
  - Data that allow for trends to be evaluated
  - Data that provide observations in relation to labeled application rates
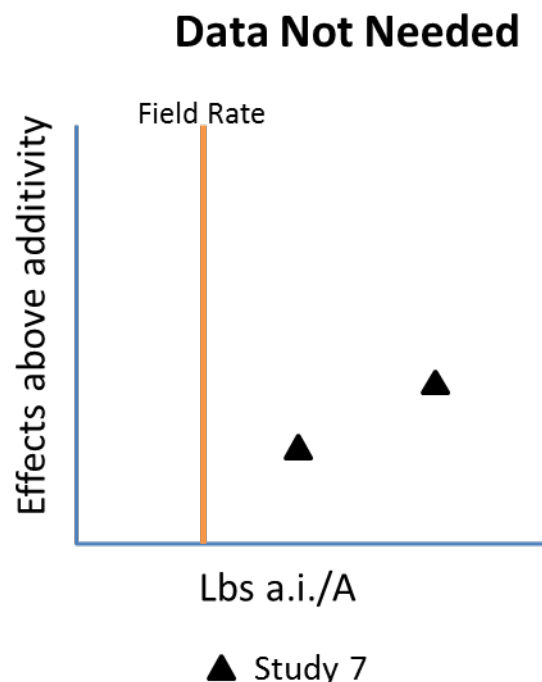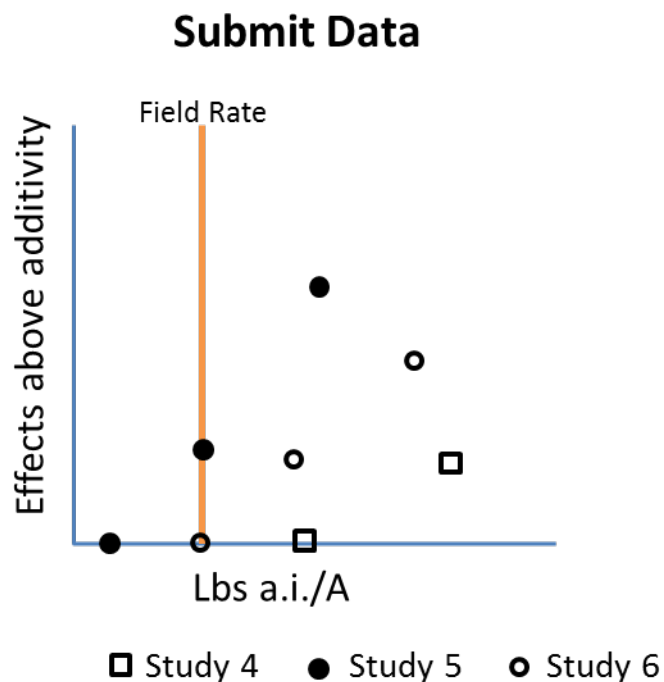
Current Relevance Criteria for Reporting

5. The patent claims "synergy" was observed in a test with three or more treatments at and above the (current or proposed) labeled field application rate

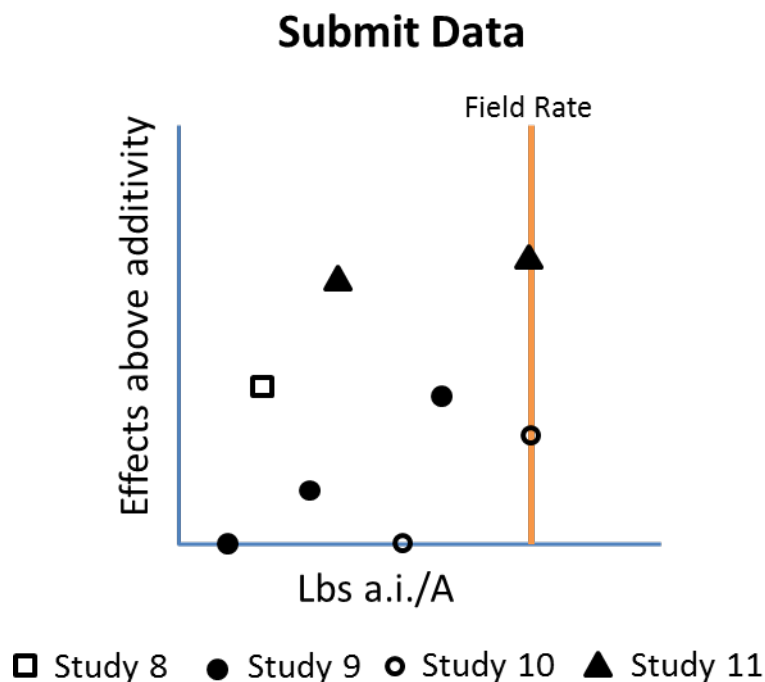**Submit Data**

Data Not Needed
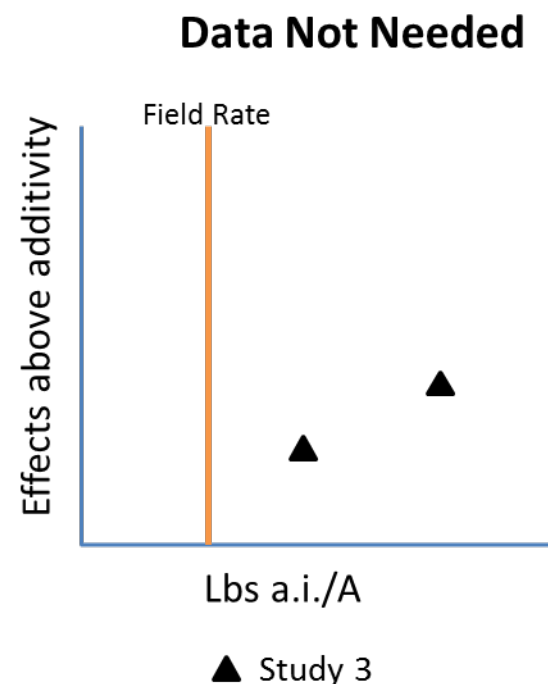
Current Relevance Criteria for Reporting

6. There are two or more treatments where the patent claims "synergy" at or above the (current or proposed) labeled field application rate, but at least one treatment in the progression did not show "synergy"

Current Relevance Criteria for Reporting

7. The patent claims "synergy" in one or more treatments at or below the (current or proposed) labeled field application rate.

Submit Data

□ Study 8   ● Study 9   ○ Study 10   ▲ Study 11

Post Processing of Submitted Patent Data

- **Evolving Process**
- Only small number of cases have gotten to data submission phase and only one has completed that phase, and for one U.S. Patent
- Underlying goal is an evaluation of the data sets to decide:
  - IF mixture toxicity results in effects that depart from theoretical additive expectations in ways meaningful to the risk assessment process
  - How much of a departure is reasonably expected at exposure levels where the risk assessment is performed
- Process at this point is driven by the data available
  - Dictates the models and assumptions for theoretical mixture toxicity
  - Affects the statistical approaches that can be applied

Conclusions

- When risks are identified based on modeled or measured offsite exposures, EPA employs refinements to the standard assessment approach to address the certainty and uncertainty.
  - Aims to integrate additional lines of evidence to support a risk conclusion
  - Generalized national assessment to geospatially refined distribution of risks, when warranted
  - Refining based on enforceable mitigation measures for reducing risk
- The evaluation of the terrestrial plant endpoints (IC_{25}, NOAEC), and the development of the Audrey III Terrestrial and Aquatic Plant Model
  - Further advance the methods to evaluate pesticide risks to plants
- EPA will continue to review patent data submitted based on draft relevance criteria presented here
  - As more data and studies are evaluated the draft criteria, data evaluation processes, and methods for integrating patent data into risk assessments are likely to evolve